TEACHER INSTRUCTIONS:

For each lab group, you'll need:

- Titration equipment
- about 20 mL 0.0188M $KMnO_4$
- about 10 mL 3M H_2SO_4
- about 1 mL FRESH hydrogen peroxide from the drugstore

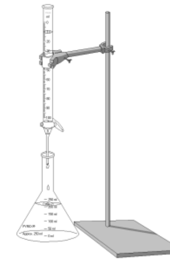
You will need to setup several burets around the room. At each buret, place a bottle of 0.0188M $KMnO_4$ so that students can quickly and easily fill the burets. Under each buret, place a magnetic stirrer, a small flask or beaker, a magnetic stir bar, and a magnetic stir bar retriever.

At the front of the room, I would place a SINGLE bottle of FRESH Hydrogen peroxide from the drug store. (Over time, peroxide decomposes, so it will not be a 3% solution if it's old). Also, have a graduated pipet and bulb at the front so students can accurately measure out their H_2O_2 volume. I would also place a single bottle of 3M H_2SO_4 at the front of the room so that students can obtain 10 mL from it.

Students will measure out 1 mL of H_2O_2 and titrate it with $KMnO_4$ in the presence of acid (H_2SO_4). From the endpoint, they can find the volume of titrant needed. Using stoichiometry, student find the grams of H_2O_2 in their 1-gram sample and find the percent.

It may be helpful to have students titrate with a WHITE background. Also, students often think that adding water changes the concentration of peroxide, but you'll need to explain that it doesn't change the MOLES of peroxide, so it won't affect the titration.

AP Chem Investigation 12 – Redox Titration Lab



Name ____ Period _______

1. Check to be sure you have at least 20 mL of $KMnO_4$ in your buret. If not, add some $KMnO_4$ to your buret.
2. Be sure there are no air bubbles in the buret. If there are, stream some $KMnO_4$ out of the buret into a waste beaker until the air bubble comes out. You can dump this solution down the sink with running water.
3. Take an initial reading of $KMnO_4$ from the buret. Record this value in the data table.
4. Measure out exactly 1.00 mL of H_2O_2 using a graduated pipet and add it to a clean flask.
5. Add 10 mL of 3M H_2SO_4 to the flask using a graduated cylinder. This is so that the titration can occur in acidic conditions.
6. Add water to the flask to bring the solution up to about 30-50mL of volume. (This is just to improve your ability to see the color change at the endpoint. Adding water will NOT affect the number of moles of H_2O_2 present in the flask, so it won't affect the volume of titrant required to reach the equivalence point).
7. Titrate the H_2O_2 to the endpoint (until a faint pink color persists). Try not to add even just 1 drop of $KMnO_4$ past the endpoint! Record the volume of titrant
8. Dump your solution down the sink. Leave the leftover $KMnO_4$ in your buret for the next class.
9. Check the label on the $KMnO_4$ bottle and record the molarity of the $KMnO_4$ solution in your data section.

Data Table

Volume of H_2O_2 titrated	1.00 ml
Initial reading of MnO_4^- volume on buret	2.00 ml
Final reading of MnO_4^- volume on buret	19.50 ml
Concentration of MnO_4^- solution on bottle	0.0188 M

Questions:

1. Balance the equation below using the half-reaction method. Show all work.

$MnO_4^-{}_{(aq)} + H_2O_{2(aq)} \quad O_{2(g)} + Mn^{2+}{}_{(aq)}$

$(5e^- + 8H^+ + \overset{+7}{Mn}O_4^- \longrightarrow Mn^{2+} + 4H_2O)\,2$

$(H_2\overset{-1}{O_2} \longrightarrow \overset{0}{O_2} + 2H^+ + 2e^-)\,5$

$\cancel{10e^-} + \cancel{16}\,6\,H^+ + 2MnO_4^- + 5H_2O_2 \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2 + \cancel{10H^+} + \cancel{10e^-}$

$6H^+ + 2MnO_4^- + 5H_2O_2 \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2$

2. What volume of MnO_4^- was added to reach the endpoint?

19.50 ml − 2.00 ml = 17.50 ml

3. Knowing the volume and concentration of $KMnO_4$, how many moles of MnO_4^- were added to reach the endpoint?

$.0175\,L \times \frac{.0188\,mol}{1\,L} = 3.29 \times 10^{-4}\,mol\ MnO_4^-$

4. Using the balanced equation, how many moles of H_2O_2 were in your sample?

$3.29 \times 10^{-4}\,\cancel{mol\ MnO_4^-} \times \frac{5\,mol\ H_2O_2}{2\,\cancel{mol\ MnO_4^-}} = 8.23 \times 10^{-4}\,mol\ H_2O_2$

5. Convert the moles of H_2O_2 into grams.

$8.23 \times 10^{-4}\,\cancel{mol\ H_2O_2} \times \frac{34.02\,g\ H_2O_2}{1\,\cancel{mol\ H_2O_2}} = 0.0280\,g\ H_2O_2$

6. Imagine that your sample of H_2O_2 was mostly water and contained very little H_2O_2 molecules. If it was mostly water, it would be expected to have a density similar to water. The density of water is 1.00 g/mL. Let's assume the sample had a density of 1.00 g/mL. Using the mass of H_2O_2 calculated in the previous question along with the fact that your sample was exactly 1.00 mL, calculate the percentage of your sample that was H_2O_2.

1.00 mL × 1.00 g/mL = 1.00 g H_2O_2

.0280 g H_2O_2 / 1.00 g × 100% = 2.80 % H_2O_2

7. The label on the bottle states that the bottle of H_2O_2 is a 3% solution. Compare this value to your calculation in the previous question. Is the label correct? Why or why not?

8. Is it necessary to know the exact volume of…

a) H_2O_2 sample added to the flask? b) water added to the flask? c) $KMnO_4$ added to the flask?

Review Questions:

1. A 25.00mL sample of oxalic acid, $H_2C_2O_4$, was titrated with a standardized solution of $KMnO_4$ under acidic conditions. To reach the endpoint, 17.30mL of 0.0200M $KMnO_4$ was needed. At that point, a pink color persisted.

$MnO_4^-{}_{(aq)} + H_2C_2O_{4(aq)} \quad CO_{2(g)} + Mn^{2+}{}_{(aq)}$

a. What does the pink color suggest?

We have reached the endpoint, where all $H_2C_2O_4$ moles have been reacted.

b. Balance the equation using the half-reaction method. Show all work.

$(5e^- + 8H^+ + \overset{+7}{Mn}O_4^- \rightarrow Mn^{2+} + 4H_2O)2$

$(H_2\overset{+3}{C_2}\overset{-2}{O_4} \rightarrow 2\overset{+4}{C}\overset{-2}{O_2} + 2e^- + 2H^+)5$

$~~10e^-~~ + ~~8H^+~~ + 2MnO_4^- + 5H_2C_2O_4 \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2 + ~~10e^-~~$ ~~10~~ 2 H^+

$2MnO_4 + 5H_2C_2O_4 \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2 + 2H^+$

c. How many moles of MnO_4^- reacted with the oxalic acid?

$.01730\ L \times \frac{.0200\ mol}{L} = 3.46 \times 10^{-4}$ mol MnO_4^-

d. Based on your previous answer, how many moles of oxalic acid were present in the original sample?

3.46×10^{-4} mol MnO_4^- $\times \frac{5\ mol\ H_2C_2O_4}{2\ mol\ MnO_4} = 8.65 \times 10^{-4}$ mol $H_2C_2O_4$

e. Calculate the molarity of the $H_2C_2O_4$ solution, given your previous answer and the fact that 25.00 mL were used?

$\frac{8.65 \times 10^{-4}\ mol}{.02500\ L} = \boxed{0.0346\ M}$

2. Our titration was performed in an acidic solution. Research the products of the redox reaction between MnO_4^- ions and H_2O_2 in a basic solution. How might the products under basic conditions impact your ability to know when you've reached the endpoint of the titration?